

# LEND PDS Data LPSC 2015

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Federal Space Agency of Russia

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# PDS Products



- PDS Geosciences node
  - <http://pds-geosciences.wustl.edu/missions/lro/lend.htm>
- EDR
  - Science – EDR\_SCI
  - Housekeeping – EDR\_HK
- PDR
  - Science with Spatial – RDR\_RSCI
  - Reduced Science – RDR\_DLD
  - Averaged Science – RDR\_ALD





```
LEND_RDR_ALD.FMT ×
OBJECT = COLUMN
  COLUMN_NUMBER = 1
  NAME = START_UTC_TIME
  DATA_TYPE = CHARACTER
  BYTES = 23
  START_BYTE = 1
  DESCRIPTION = "UTC time at the start of the averaged frames,
stored as yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 2
  NAME = STOP_UTC_TIME
  DATA_TYPE = CHARACTER
  BYTES = 23
  START_BYTE = 24
  DESCRIPTION = "UTC time at the end of the averaged frames,
stored as yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 3
  NAME = LUNARCENTRIC_LATITUDE
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 47
  UNIT = DEGREE
  DESCRIPTION = "Latitude in LUNAR fixed coordinates at the
center of the given map element."
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 4
  NAME = LUNARCENTRIC_EAST_LONGITUDE
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 51
  UNIT = DEGREE
  DESCRIPTION = "Longitude in Lunar fixed coordinates at the
center of the given map element."
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 5
  NAME = EXPOSURE
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 55
  UNIT = SECOND
  DESCRIPTION = "Exposure time of given map element, sec."
```

```
LEND_RDR_DLD_FMT ×
OBJECT = COLUMN
  COLUMN_NUMBER = 1
  NAME = LRO_TIME
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 8
  START_BYTE = 1
  DESCRIPTION = "5 upper bytes of LRO time."
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 2
  NAME = UTC
  DATA_TYPE = CHARACTER
  BYTES = 23
  START_BYTE = 9
  DESCRIPTION = "UTC time at the middle of the collection interval,
  stored as yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN


OBJECT = COLUMN
  COLUMN_NUMBER = 3
  NAME = LOCAL_HOUR
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 1
  START_BYTE = 32
  UNIT = MINUTE
  DESCRIPTION = "Local Sun hour at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 4
  NAME = LOCAL_MINUTE
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 1
  START_BYTE = 33
  UNIT = MINUTE
  DESCRIPTION = "Local Sun minute at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 5
  NAME = LUNARCENTRIC_LATITUDE
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 34
  UNIT = DEGREE
  DESCRIPTION = "Latitude in LUNAR fixed coordinates at the middle
  of the frame."
END_OBJECT = COLUMN
```





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# PDS Geosciences Node

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## Services

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  - Lunar Spectroscopy
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## Help

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## Scheduled Maintenance

This site may be down on **Thursdays** between 7:00 and 9:30 pm Central Time for maintenance.

## LRO: LEND

**March 13, 2015.** LRO Release 21 includes new LEND EDR and RDR data acquired between September 15 and December 14, 2014, and new DLD data acquired between June 15 and September 14, 2014. See [ERRATA.TXT](#) for details.

LEND is the Lunar Exploration Neutron Detector, which measures the flux of neutrons from the lunar surface. LEND data sets are produced by the LEND Science Team at the University of Arizona, Tucson, AZ.

### LEND Data Sets


Raw Data Products

EDR - Experiment Data Records

Derived Data Products

RDR - Reduced Data Records

### Online Tools



[Lunar Orbital Data Explorer](#) - Provides search, display, and download tools for LRO LEND data sets.

[LEND PDS Data Viewer](#) - Download this software tool developed by the University of Arizona Lunar and Planetary Laboratory for browsing and displaying LRO LEND PDS data files. For Windows systems running Java 1.6 or higher.

[LEND PDS Data Viewer User's Guide](#) (PDF, 1.6 MB)

[LEND PDS Data Viewer Setup File](#) (2.9 MB)

### Related Information

Data Processing

LEND Data Processing Document (PDF, 4MB) (HTML)

PDS Catalog Files

EDR Dataset Description

RDR Dataset Description

LEND Instrument Description

Personnel

References


Software Interface Specifications (SISs)

LEND EDR Data Product SIS (PDF, 373 KB)

LEND RDR Data Product SIS (PDF, 848 KB)

LEND Archive Volume SIS (PDF, 193 KB)

LEND Team Web Site



# Lunar Orbital Data Explorer

## PDS Geosciences Node

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DATA PRODUCT SEARCH

Planetary science data stored in PDS is organized by [data products](#) and [data sets](#). A data set is a collection of related data products, usually products acquired by a particular instrument and processed in a certain way. The data set also includes all documentation and supporting materials needed to understand and use the data products. A data product is a set of measurements resulting from a science observation, usually products acquired by a particular instrument and processed in a certain way.

STEP 1. SELECT DATA SETS TO SEARCH (A SELECTION IS REQUIRED)

☐ Map location data is available for these products.
 ☐ Observation time data is available for these products.
 ☐ Product emission, incidence, and phase angle data is available for these products.
 ☐ Solar longitude data is available for these products.

Lunar Reconnaissance Orbiter

DLRE - Lunar Radiometer Experiment

☐ RDR - Reduced Data Rec. (See Tools: DIVINER RDR Query Tool)
 ☐ GDR\_L2 - Gridded Data Record Level 2
 ☐ GDR\_L3 - Gridded Data Record Level 3
 ☐ PRP - Gridded Data Record Polar Resource Products

Other Product Types

LAMP - Lymap Alpha Mapping Project

☐ RDR - Reduced Data Record
 ☐ GDR - Gridded Data Record

Other Product Types

LEND - Lunar Exploration Neutron Detector

☐ RDRALD - Average Lend Counts Data Reduced Data Record
 ☐ RDRCHK - Converted Housekeeping Data Reduced Data Record
 ☒ RDRDL - Derived Lend Counts Data Reduced Data Record
 ☐ RDRRSCI - Rectified Science Data Reduced Data Record

Other Product Types

LOLA - Lunar Orbiter Laser Altimeter

☐ RDR - Reduced Data Rec. (See Tools: LOLA RDR Query Tool)
 ☐ GDRDEM - Gridded Data Record Shape Map
 ☐ GDRDEC - Gridded Data Record Counts
 ☐ GDRDRM - Gridded Data Record Roughness Map
 ☐ GDRDSM - Gridded Data Record Slope Map

Other Product Types

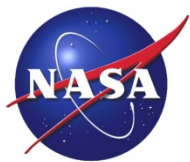


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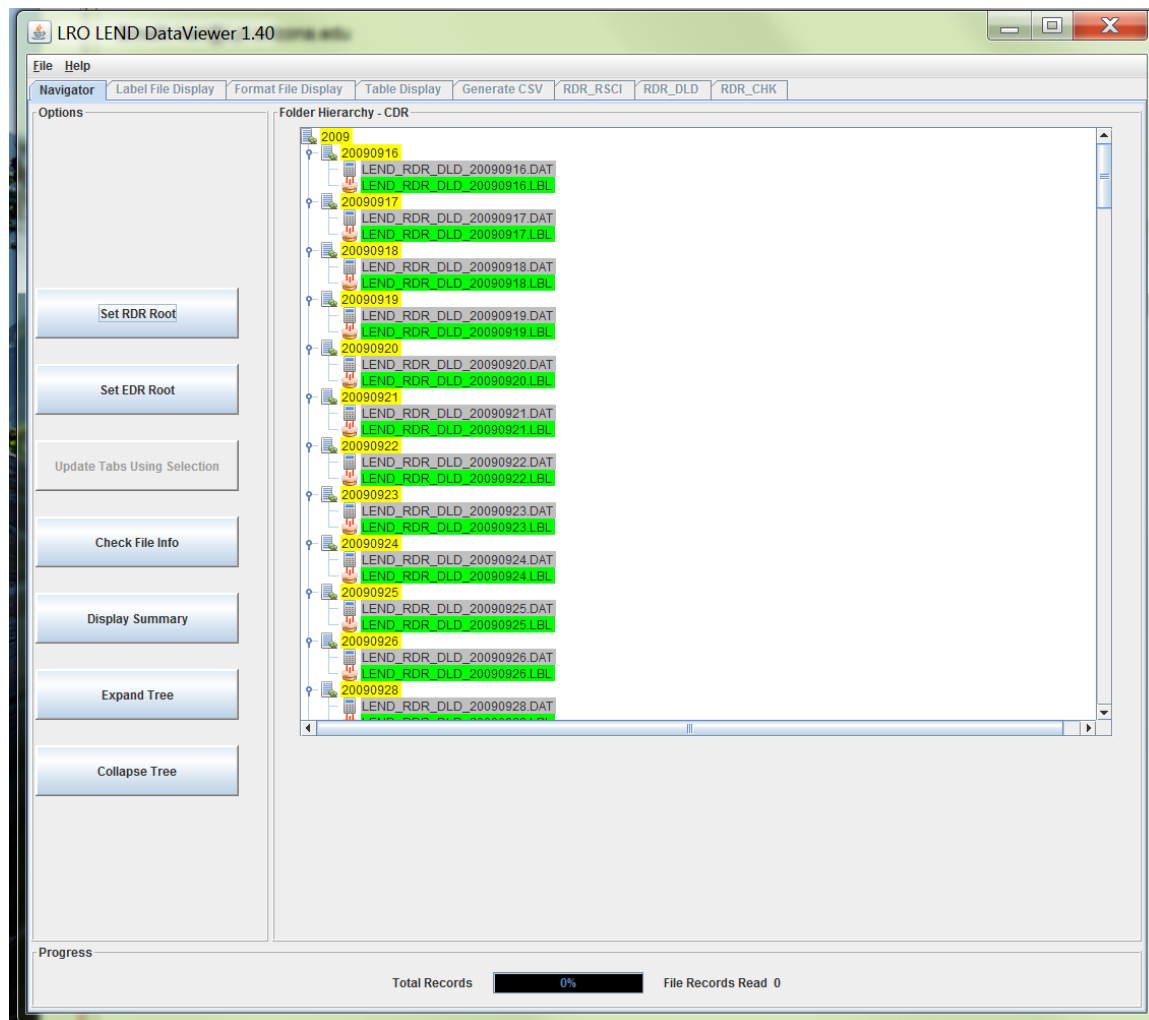




# Available Tools



- NASA View
  - PDS provided
- LEND PDS Viewer
  - University of Arizona provided



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# How data can be used



- DLD – the building blocks to maps
  - Spatially
  - Temporally



Caption for Figure on Slide 3

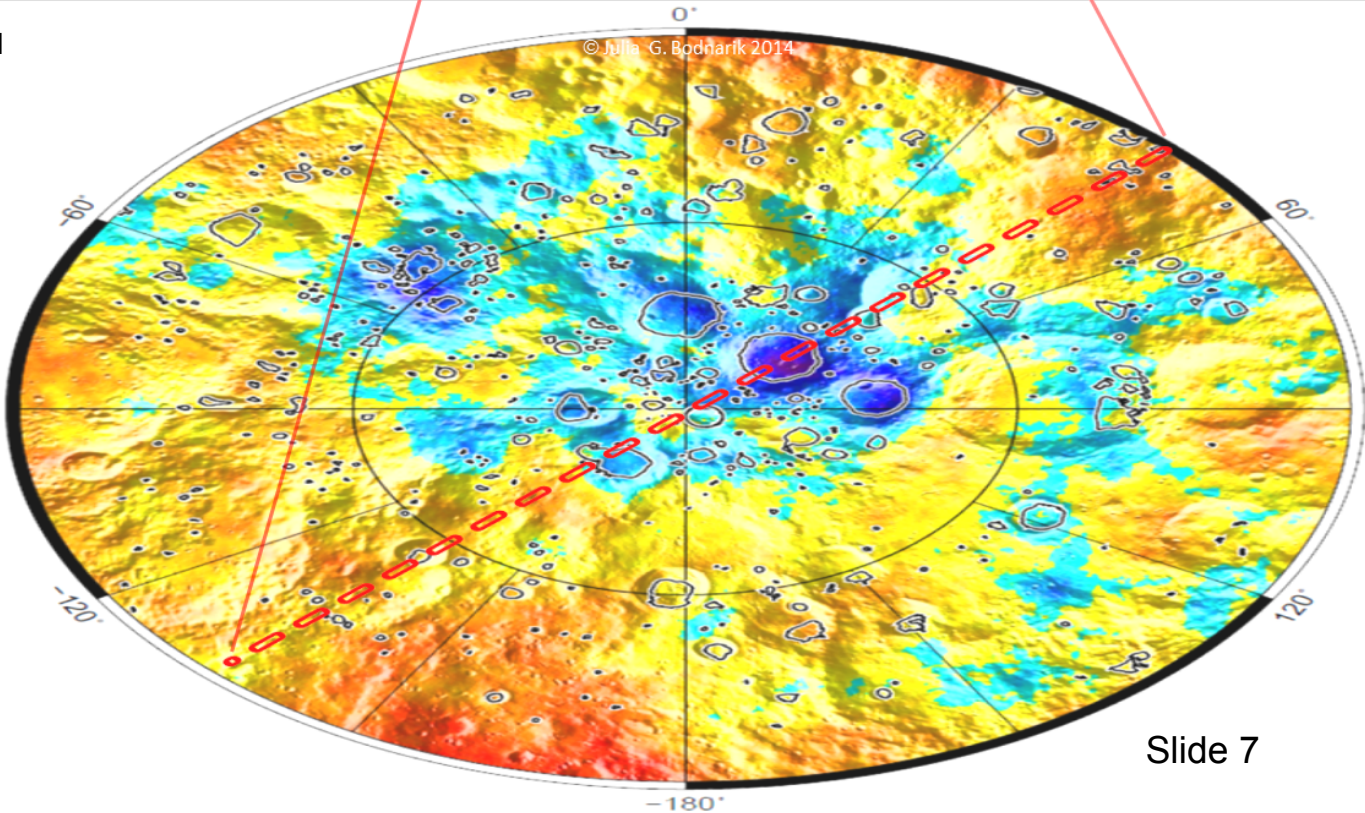
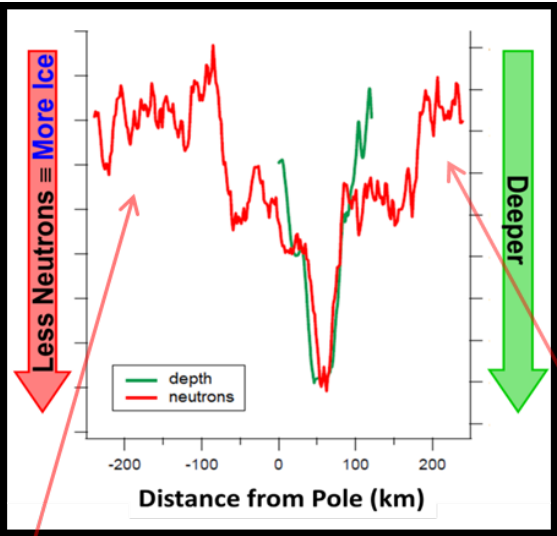
LEND South Pole Hydrogen Deposits and Lunar Topography: A trace of a LRO spacecraft orbital track – shown above in red on the LEND hydrogen South pole topography map – through the Shoemaker crater neutron suppressed region. The plot shows that the neutron suppression – shown in green – corresponds directly with the Shoemaker crater LRO topography – shown in red.

The bottom lunar SP map was created using IDL and GMT in the following way:

- 1. Created SP LEND CSETN v294 boxcar smoothed polar stereographic map.
- 2. Converted cps map to H ppm map and performed a uniform background subtraction.
- 3. Exported data into GMT format for mapping
- 4. Using GMT, overlayed LEND data (shown in color) on top of LOLA topography and added PSRs.
- 5. Added trace for top graph to the plot.

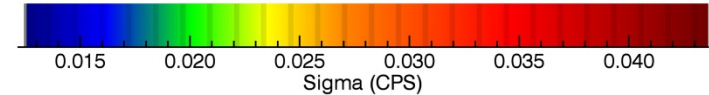
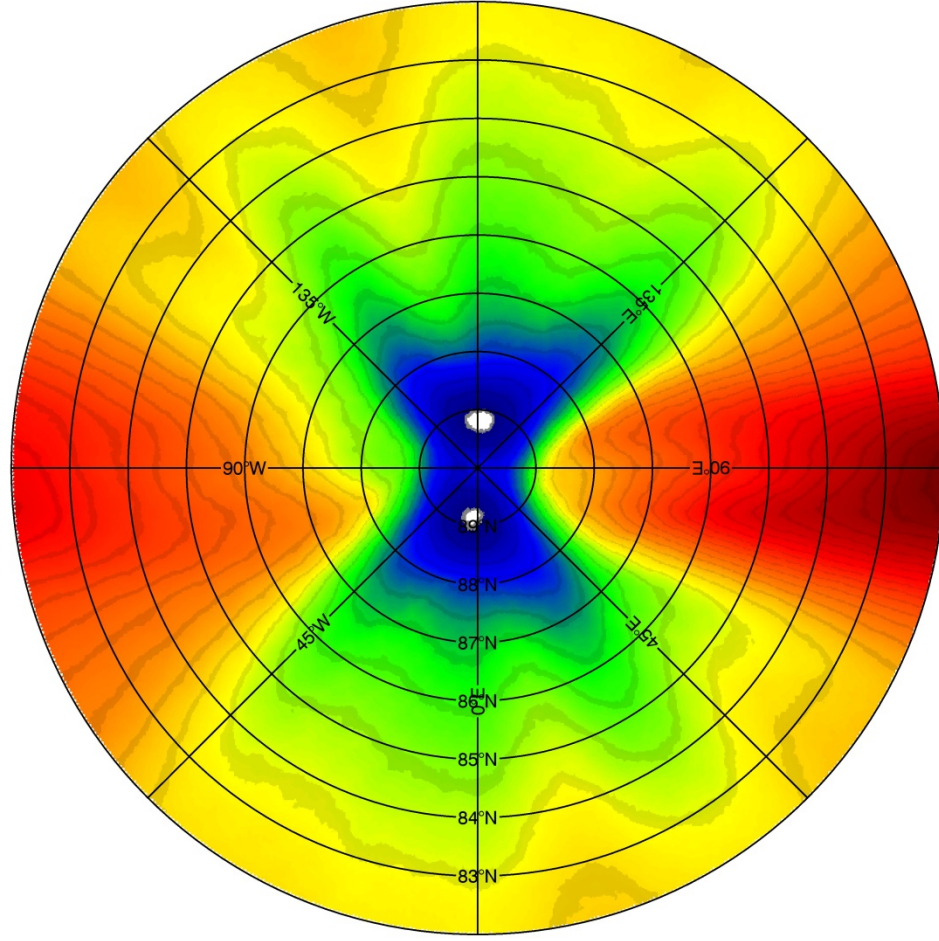
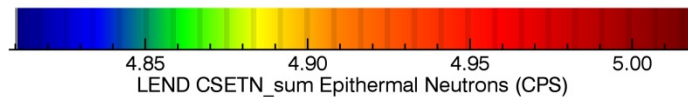
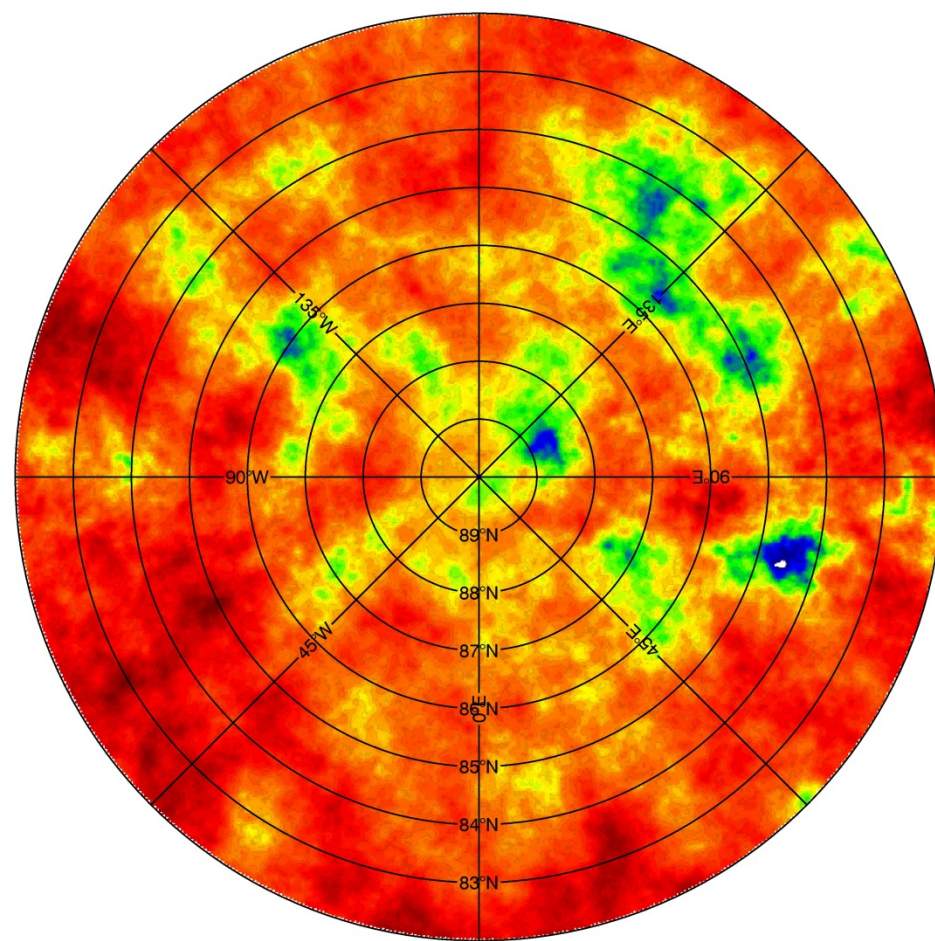
Top plot was created in the following way:

- 1. Used IDL to do LOLA and LEND traces through Shoemaker crater as a function of distance in km from the pole.
- 2. Exported data to Igor pro to create plot.





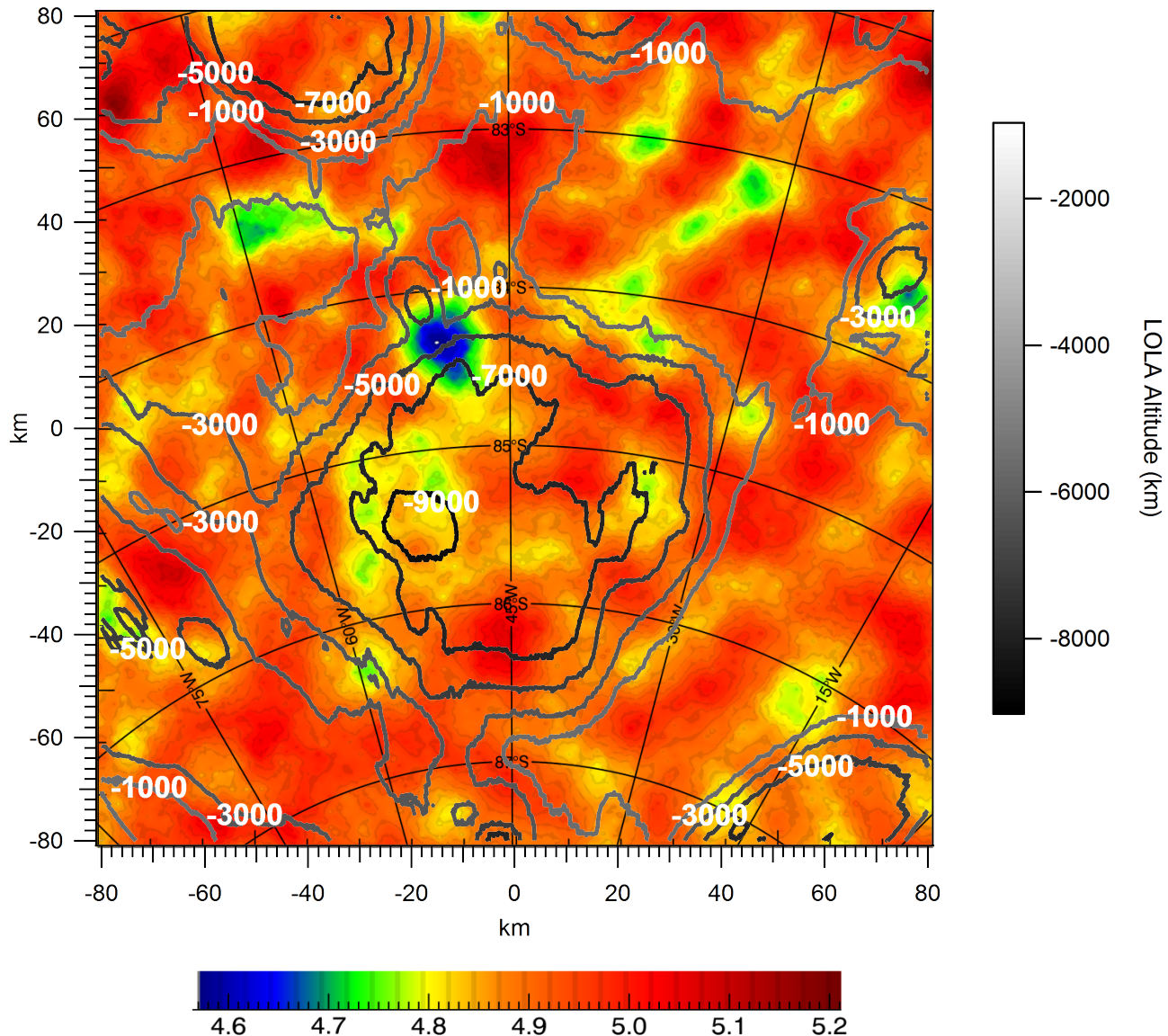
Created using IDL.



LOLA Elevation Contour Map Overlay on LEND Epithermal Neutron Smoothed WM Map  
(South Pole, Cabeus crater region, [c\_lat, c\_lon] = [-44.7, -84.9], extent = 80 km)

This LEND CSETN Gaussian smoothed weighted mean map was created in the following way :

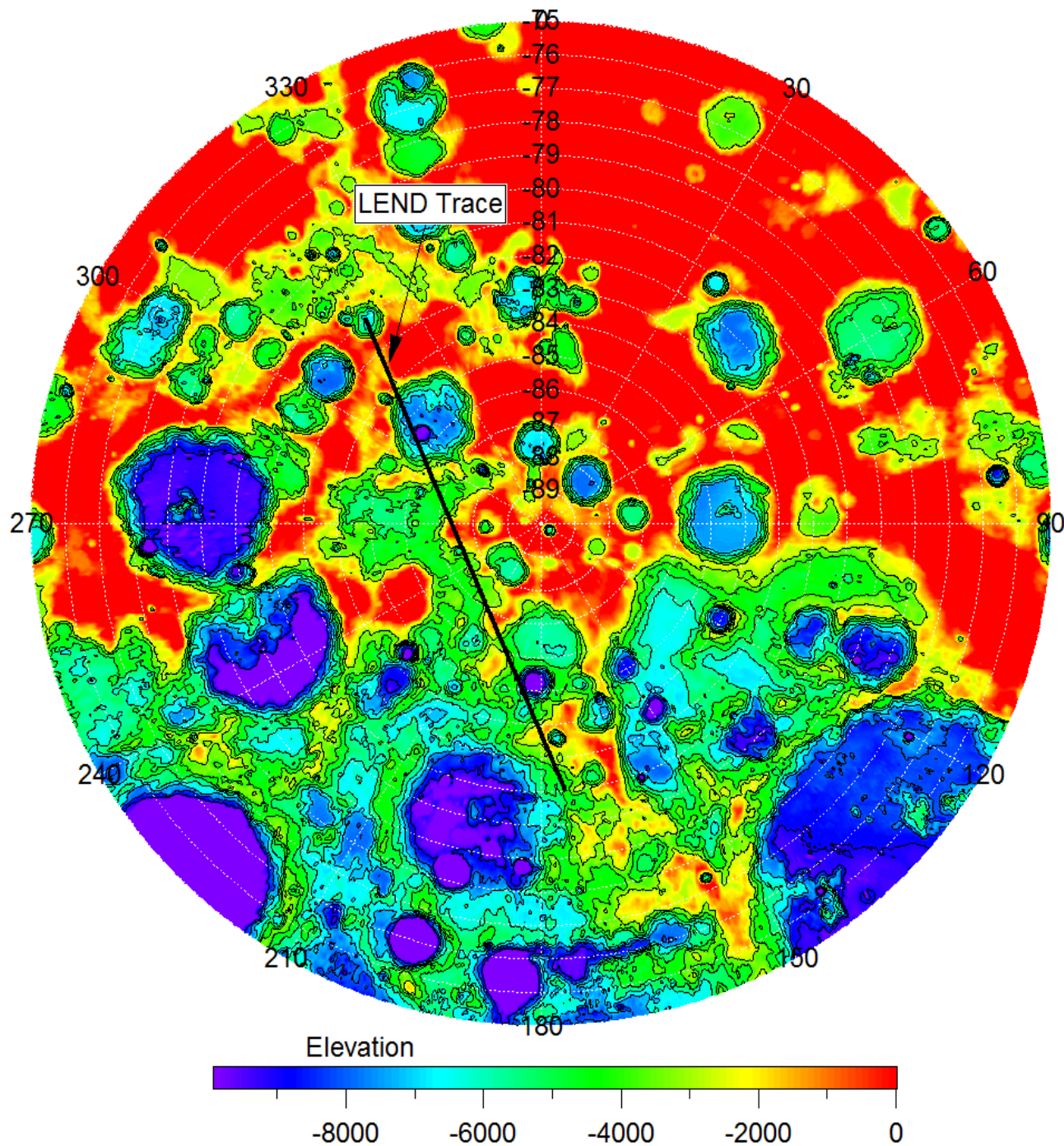
1. Used IDL to create a km map centered on Cabeus crater with a polar stereo graphic grid overlaid on the map.
2. Exported LEND image into Igor Pro.
3. Imported LOLA data for the region into Igor Pro.
4. Created LOLA contour map and overlayed it on LEND image in Igor Pro.
5. Added legends



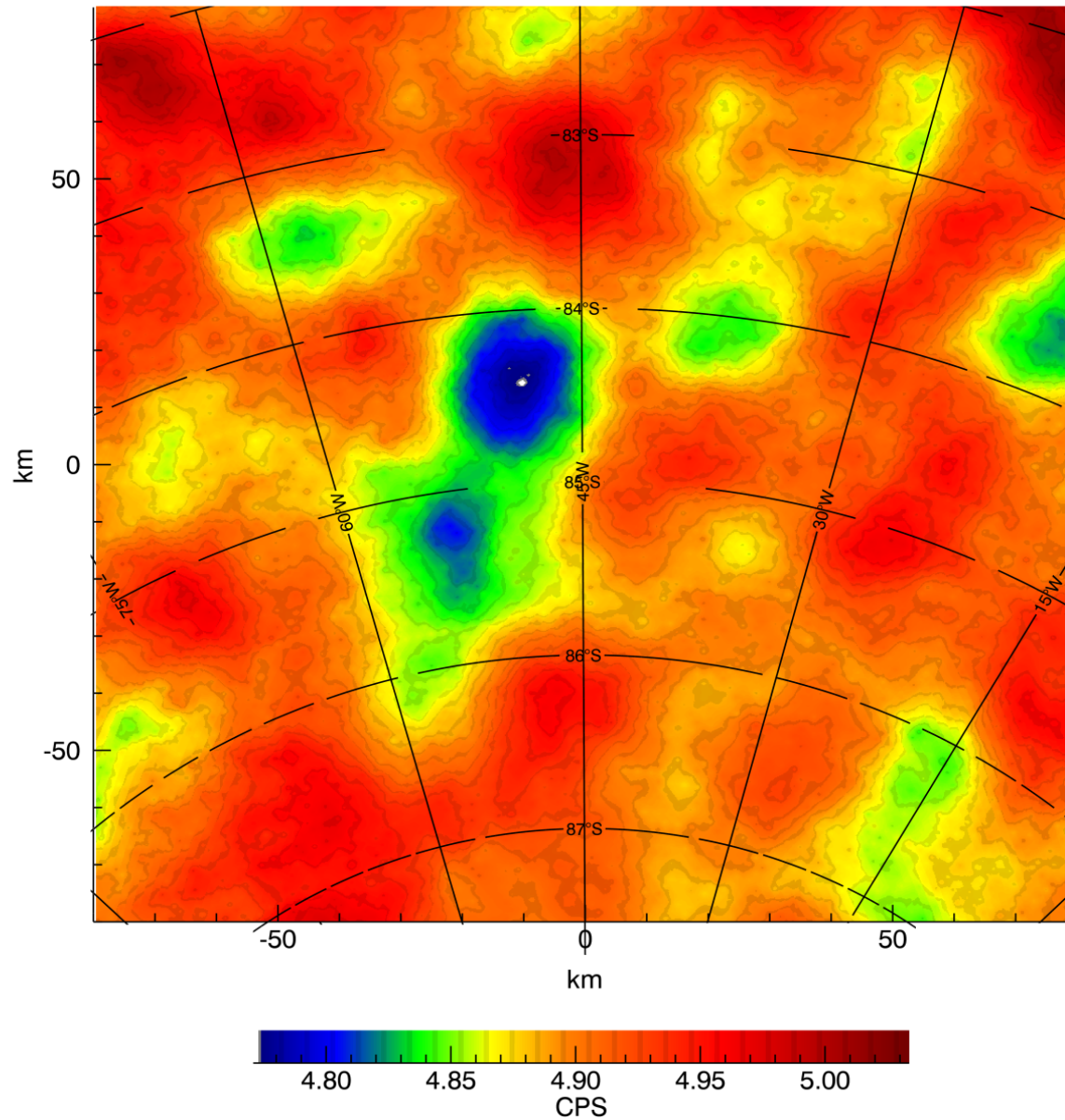


This LEND  
CSETN  
smoothed  
weighted mean  
map was  
created in the  
following way :

1. Used IDL to  
create  
smoothed  
wm map  
and  
exported  
data LEND  
and LOLA  
data to Igor  
Pro.
2. Used Igor  
pro to create  
LEND data  
map with  
LOLA  
contour  
overlay



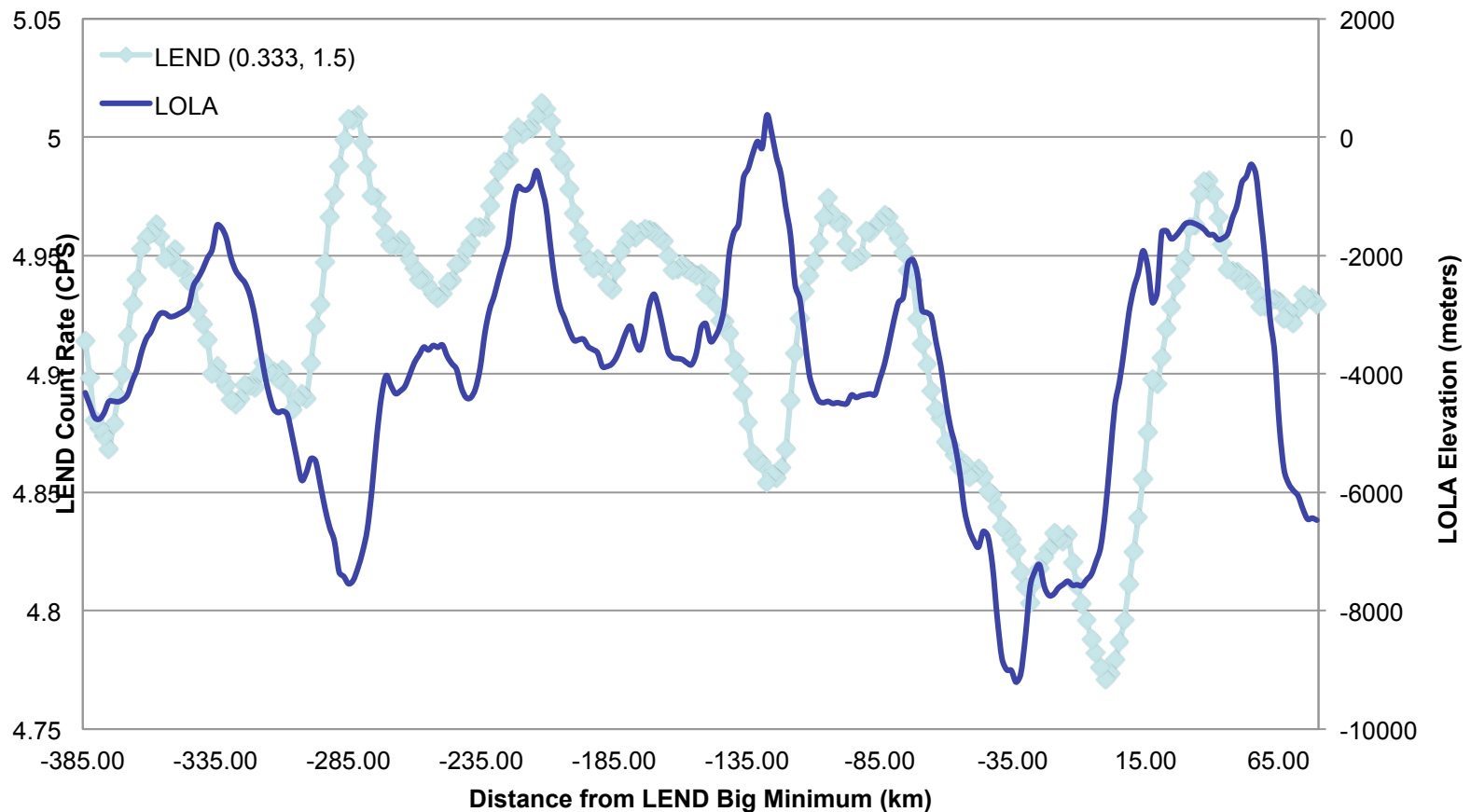
Cabeus Gaussian Smoothed WM Map (smoothing degree = 0.333, sigma reach = 1.5  
([center lat, center lon] = [-84.9, -44.7], extent = 80 km, South Pole, /interp)





This trace was created using IDL  
and exporting data into Excel. The  
corresponding LEND IDL images  
are to the left

### Trace Cabeus Two Minima

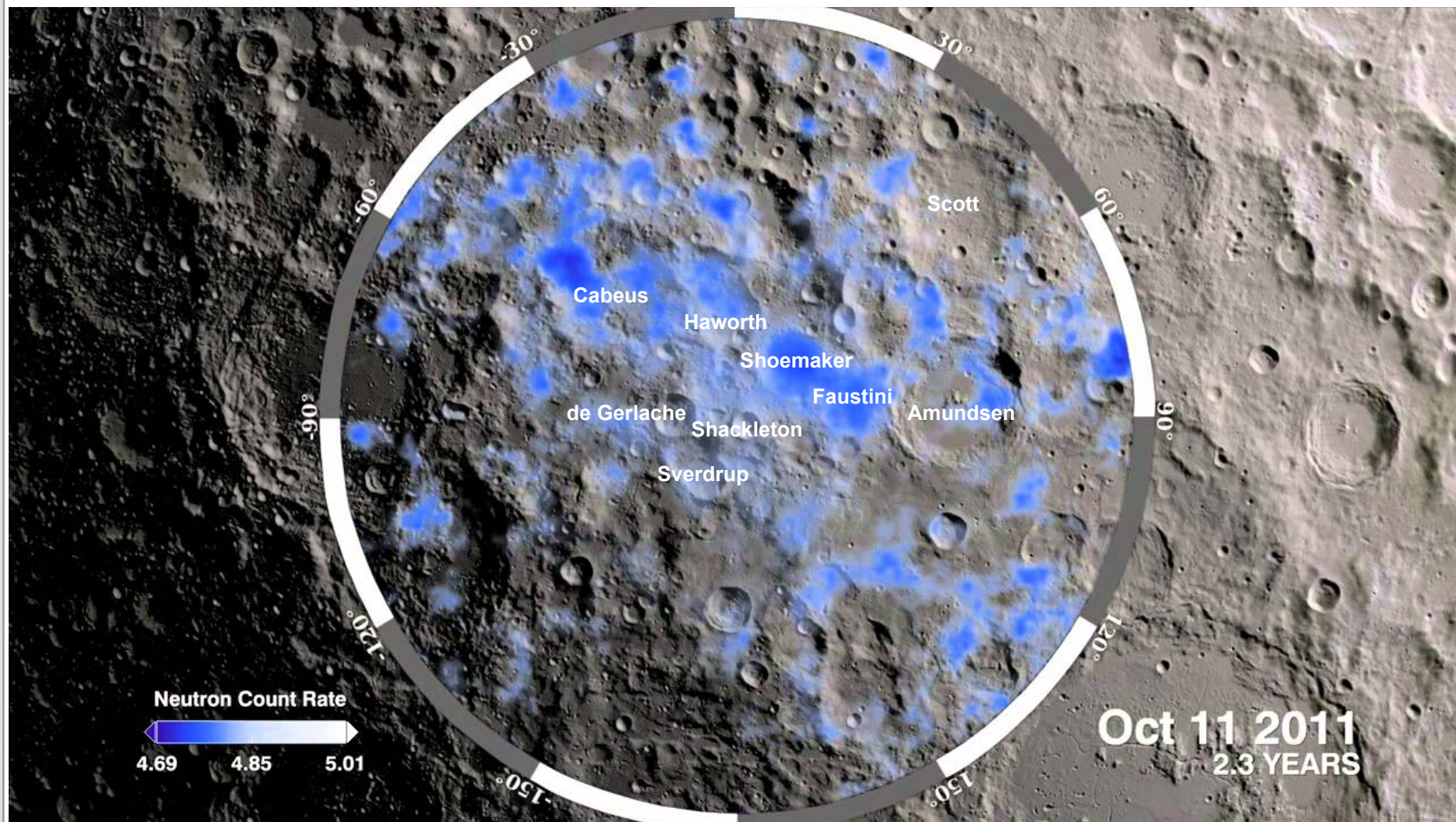




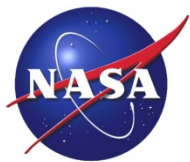
Polar Ice Deposits: LRO evidence shows that the Moon's polar regions, especially PSRs, are cold enough to retain water ice. Over several years, LEND has scanned the Moon's South pole measuring how much hydrogen is trapped in the soil. Areas with suppressed neutron activity – shown above in blue – show the highest concentration of hydrogen atoms, strongly suggesting the presence of  $H_2O$  molecules.

This image is a snapshot of the lunar SP created for a NASA Goddard Space Flight Center movie for Tim McClanahan. It is an overlay of LEND CSETN data (shown in the blue to white continuum) created using IDL on lunar topography. The names of the craters were also added to the image.









# Animation



- South Pole fly-in

